ORGANIZATIONAL INSTRUCTION

MAINTAINABILITY ALLOCATION

OPR(s)	**OPR DESIGNEE**
QD10, QD20, QD30, QD40	Prince Kalia

DOCUMENT HISTORY LOG

Status (Baseline/ Revision/ Canceled)	Document Revision	Effective Date	Description
Baseline		11/19/97	
Revision	A	7/1/99	Changes made to reflect new organization code changes and/or Changes made to reflect new directives renumbering scheme
Revision	B	7/1/01	Changed OPR and OPR Designee. Revised Quality Records table.
Revision	C	9/04/02	Format and numbering change to implement requirements of QS-A-001 rev F.
Revision	D	10/20/03	Added applicable documents. Revised section 4 to add detail to maintainability allocation process.
Revision	E	10/15/04	Updated OI to implement HQ Rules Review in accordance with CAITS Action # 04-DA-01-0387) (Utilizing the word "Shall" for all requirements, removing ambiguity, removing non-requirements, etc.)

Maintainability Allocation

1. PURPOSE, SCOPE, APPLICABILITY

1.1 Purpose

The purpose of this Organizational Instruction (OI) is to describe the process that shall be used for Maintainability Allocation for the design, development, and operation phases of all flight hardware and flight support equipment.

1.2 Scope

This OI describes the S&MA responsibility that shall be performed for flight hardware/software for Maintainability Allocation. Maintainability Allocation is performed to translate a system level quantitative maintainability requirement or goal into more meaningful, lower-level (subsystem and component) requirements.

1.3 Applicability

This OI is applicable to all S&MA personnel supporting MSFC programs/projects with quantitative maintainability requirements.

2. DOCUMENTS (Applicable and/or Reference)

2.1 Applicable Documents

NPD 8720.1	NASA Reliability and Maintainability (R&M) Program Policy
NASA-STD-8729.1	Planning, Developing and Managing an Effective Reliability and Maintainability (R&M) Program

2.2 Reference Documents

MKIT	Maintainability Toolkit: A Practical Guide for Designing and Developing Maintainable Products and Systems, published by the Reliability Analysis Center
MPG	Maintenance Planning Guide – Air Force Aeronautical Systems Center – 1 Nov 2001

3. DEFINITIONS

All definitions applicable to this OI are addressed in NASA-STD-8729.1

4. INSTRUCTIONS

At the system level, quantitative maintainability requirements are typically expressed in terms of Inherent Availability or Mean Maintenance Crew time. These are appropriate performance requirements at the system level, but are meaningless to an equipment designer. Therefore, these requirements are decomposed and allocated in terms that are meaningful to the equipment designers. At the equipment level, maintainability is typically specified in terms of Mean Time To Repair (MTTR). Reference document (1) is an excellent source of additional information regarding maintainability allocation.

4.1   Availability Allocation

Inherent availability is a measure of system operational readiness, and is a function of how reliable a system is and how long it takes to repair the system when it fails. Mathematically, Inherent Availability can be represented as:

$$A = \frac{MTBF}{MTBF + MTTR}$$

where MTBF is Mean Time Between Failure, and
    MTTR is Mean Time To Repair.

The system level Availability requirement is suballocated to the subsystems that make up the system. This can be done using the apportionment technique, whereby weighting factors are used to apportion the system availability among its subsystems. Selection of weighting factors is based on relative complexity of each subsystem (i.e, if subsystem A is twice as complex as subsystem B, the weighting factor for subsystem A should be twice the weighting factor of subsystem B).

$$A_j = A^{\left(\frac{w_j}{\sum_{i=1}^{n} w_i}\right)}$$

where A_j is the Availability of subsystem j;
        A is the system Availability;
        w_j is the weighting factor assigned to subsystem j; and
        n is the number of subsystems

For a given subsystem availability, values for MTBF and MTTR can be derived and allocated to the components that make up the subsystem to serve as meaningful design requirements.

4.2   Mean Maintenance Crew-time Allocation

Mean Maintenance Crew-time is the total Crew-time required to perform maintenance on a system in a specified time period (typically per year). For a given system or subsystem MMCY, values for MTBF and MTTR can be derived and allocated to the components that make up the system to serve as meaningful design requirements.

4.3   Maintainability Allocation Process

Maintainability allocation is an iterative process. The feasibility of achieving the initial set of allocated values is evaluated, and if the allocated values are not reasonable, the allocation is revised. The ability of the design to satisfy the maintainability allocations is continuously reviewed throughout the design development activities to ensure that the current design is reflected. If maintainability predictions show that any of the maintainability allocations are not met, the design shall be modified, if feasible, or allocations can be readjusted if there is sufficient margin available. The maintainability allocation process is outlined below and illustrated in the Flow Diagram in Section 11.

Step	Action
4.1	Define system maintainability requirement or goal.
4.2	Establish subsystem maintainability weighting factors.
4.3	Perform subsystem allocation.
4.4	Perform maintainability predictions.
4.4.1	Determine if maintainability requirements or goals are met.
4.4.2	Determine if re-allocation is feasible.
4.4.3	Re-allocate maintainability.
4.4.4	Determine if requirements or goals are met.
4.4.5	Determine if design changes are feasible.
4.4.6	Incorporate design changes.
4.4.7	Management accepts design risk.
4.5	Final system/subsystem requirement or goal.

5.   NOTES

The Safety and Mission Assurance (S&MA) Directorate shall coordinate the selection and tailoring of the allocation processes in this OI with the appropriate MSFC program office and engineering organization.

5.1 Records

Record	Repository	Period of Time
Maintainability Allocation Report	As specified by the project plan.	As specified by the project plan.

6.   SAFETY PRECAUTIONS AND WARNING NOTES

None.

7.   APPENDICES, DATA, REPORTS, AND FORMS

None.

8. RECORDS

None

9. TOOLS, EQUIPMENT, AND MATERIALS

The user shall define any tools, special equipment, or materials used during the maintainability allocation process.

10. PERSONNEL TRAINING AND CERTIFICATION

Training shall include maintainability allocation and analysis.

11. FLOW DIAGRAMS

The following flow diagram represents the Maintainability Allocation process outlined in Section 4.

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                              ┌─────────┐
                              │  Start  │
                              └────┬────┘
                                   │              4.1
                           ┌───────▼────────┐
                           │ Define System  │
                           │ Maintainability│
                           │Requirement/Goal│
                           └───────┬────────┘
                                   │              4.2
                           ┌───────▼────────┐
                           │   Establish    │
                           │   Weighting    │
                           │    Factors     │
                           └───────┬────────┘
                                   │              4.3
                           ┌───────▼────────┐
                           │    Perform     │
                           │System/Subsystem│
                           │   Allocation   │
                           └───────┬────────┘
```

Start

4.1 Define System Maintainability Requirement or Goal

4.2 Establish Weighting Factors

4.3 Perform System/Subsystem Allocation

4.4 Perform Prediction

4.4.1 Are Requirements/Goals Met? — YES

NO

4.4.2 Re-allocation Feasible? — NO

YES

4.4.3 Re-allocate Maintainability

4.4.4 Maintain. Req./Goals Met? — NO

YES

4.4.5 Design Changes Feasible? — NO

YES

4.4.6 Incorporate Design Changes

4.4.7 Mgmt. Accepts Risk

4.5 Final System/Subsystem Req. or Goal

End